EFFECT OF YOGIC INTERVENTION ON MUSCLE FATIGUE AND MUSCLE SORENESS OF FEMALE ATHLETES

By

Lata Apara Deori

Registration No.: PH2018-107

Co-Supervisor
Dr. Srinivasana Lakshmi Kandhan
Assistant Professor,
Department of Yoga Therapy,
Physiology, Morarji Desai National Institute
of Yoga, New Delhi

Supervisor
Dr. Payel Das
Assistant Professor,
Department of Exercise
Lakshmibai National Institute of
Physical Education, Gwalior

A

Synopsis

submitted to

Department of Yogic Sciences

Lakshmibai National Institute of Physical Education, Gwalior, (M.P.), India

For the award of the Degree of

Doctor of Philosophy in Yoga

May, 2022

Department of Yogic Sciences

Certificate

I hereby declare that the synopsis ***"Effect of Yogic Intervention on Muscle Fatigue and Muscle Soreness of Female Athletes"*** being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Yogic Sciences under Department of Yogic Sciences of Lakshmibai National Institute of Physical Education, Gwalior, MP, India, during the academic year 2021 2022. It is a bona fide record of original work carried out under the supervision of Dr. Payel Das and co-supervision of Dr. Srinivasan Lakshmi Kandhan, and has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that the synopsis is plagiarism-free and the proof has been submitted.

(Lata Apara Deori)
PH2018-107

Supervisor,
Dr. Payel Das,
Assistant Professor,
Department of Exercise Physiology,
Lakshmibai National Institute of Physical Education, Gwalior, M.P., India

Co-supervisor,
Dr. Srinivasana Lakshmi Kandhan,
Assistant Professor,
Department of Yoga Therapy,
Morarji Desai National Institute of Yoga, New Delhi, India

(Chairman, DRC)

Abstract

This study aims to investigate the impact of a structured yogic intervention on the activation levels of specific core and lower limb muscles in female athletes. A sample of forty five female athletes, aged between 18 and 22 years, from LNIPE Gwalior will be randomly selected and divided into three groups: two experimental groups and one control group, each consisting of fifteen participants. Muscle activation will be measured using Surface Electromyography sEMG, while pain intensity will be assessed through the Visual Analogue Scale. Statistical analysis will be performed using a Two-Way Repeated Measures ANOVA Mixed Design, with a significance threshold set at 0.05. The objective of this study is to enhance the understanding of muscle activation patterns and evaluate the effectiveness of targeted training programs in improving performance and alleviating discomfort among female athletes.

Keywords: *Muscle Fatigue, Electromyography, Yoga, Deep Relaxation Technique, Cyclic Meditation.*

Language: *English*

TABLE OF CONTENT

TOPICS	PAGE NO.
CHAPTER- I (INTRODUCTION)	
1. INTRODUCTION OF THE TOPIC	1-3
2. STATEMENT OF THE PROBLEM	3
3. OBJECTIVES OF THE STUDY	3
4. RESEARCH QUESTION	3-4
5. HYPOTHESIS OF THE STUDY	4
6. DELIMITATION OF THE STUDY	4
7. DEFINITION AND EXPLANATION OF TERMS	4-5
8. SIGNIFICANCE OF THE STUDY	5
CHAPTER II (REVIEW OF RELATED LITERATURE)	6-7
CHAPTER III (METHODOLOGY)	
1. SELECTION OF SUBJECTS	8
2. SELECTION OF VARIABLES	8
3. SELECTION OF INSTRUMENTS	8
4. DESCRIPTION AND ADMINISTRATION OF TESTS	9
5. COLLECTION OF DATA	9
6. STATISTICAL ANALYSIS	9
7. EXPECTED OUTCOME	10
REFERENCES	11-12

CHAPTER-I

INTRODUCTION

Swami Vivekananda highlighted the pivotal role of yoga in enhancing an individual's spiritual development. While every being experiences a continuous evolution, yoga provides a deliberate and structured approach to expedite this process. Through committed yogic practices, it is believed that one can surpass the confines of the physical body and attain liberation (moksha) within a single lifetime. The term Yoga originates from the Sanskrit root 'Yuj', which signifies to join or unite. Essentially, yoga represents the union of the individual self (jivatman) with the universal consciousness (paramatman). This integration necessitates the alignment of the body, mind, and spirit. The purpose of yoga extends beyond mere physical or mental health; it also aims at spiritual enlightenment. Although yoga is commonly linked to asanas (postures) and pranayama (breath control), it encompasses a wider spectrum that includes mudras (gestures), bandhas (energy locks), shatkarmas (cleansing techniques), and meditation, particularly within the Hatha Yoga tradition. In recent times, yoga has achieved international acclaim due to its diverse benefits. It provides mental clarity for those with restless minds, healing for the ill, and vitality for the average person. Additionally, individuals engage in yoga to enhance cognitive abilities such as memory, intelligence, and creativity. With its various benefits, yoga is increasingly becoming integrated into global awareness and serves as a means for personal growth. Relaxation techniques form an essential aspect of yogic practice. These methods consist of systematic approaches aimed at alleviating stress, muscular tension, and mental exhaustion. They contribute to lowering blood pressure, decreasing heart and respiration rates, and fostering a profound sense of tranquility. Two extensively researched yogic relaxation techniques are Cyclic Meditation (CM) and the Deep Relaxation Technique (DRT).

Cyclic Meditation, created by Dr. H.R. Nagendra and Dr. R. Nagarathna in 2003, integrates gentle yoga postures with intervals of supine rest. This method alternates between stimulation and relaxation, enabling practitioners to stay attuned to physiological changes such as heart rate, breathing patterns, and muscle tension. The Deep Relaxation Technique (DRT), usually performed in Savasana, fosters comprehensive relaxation and the connection between mind and body through breath awareness. It is particularly beneficial when practiced for a minimum of 15 minutes following physical activity, as it aids in alleviating accumulated

tension while preserving muscle strength. Muscle fatigue is a significant topic within exercise physiology. Prof. Bills, in 1943, categorized fatigue into subjective (influenced by psychological factors), objective (related to performance), and physiological fatigue. The complexity of muscle fatigue during prolonged isometric tasks arises from various interacting mechanisms. Researchers have faced challenges in determining whether fatigue originates from the muscle itself or the nervous system. Additionally, measurement using surface electromyography (sEMG) is frequently hindered by signal misinterpretation and technical inconsistencies, as noted by McManus et al. in 2020. Yoga-based practices have demonstrated an increase in oxygen consumption without elevating blood lactate levels, suggesting enhanced aerobic efficiency. Asanas can strengthen muscles, particularly in the spinal and postural regions, and improve balance. Research indicates that practices such as Surya Namaskar enhance muscle endurance, and yoga interventions can lead to significant improvements in strength assessments, including curl-ups and push-ups, as reported by Shiraishi et al. in 2016.

Surface Electromyography (sEMG) serves as an essential instrument for evaluating muscle functionality, fatigue, and activation patterns. It aids in identifying muscle firing sequences, examining force relationships, and recognizing electrophysiological indicators of fatigue. Nevertheless, the interpretation of these signals necessitates a comprehensive grasp of signal processing and biophysical concepts, which can present challenges for professionals lacking an engineering background. Addressing this interdisciplinary divide is vital for the effective application of sEMG in the fields of sports science and rehabilitation. Numerous studies have highlighted the therapeutic advantages of yoga in reducing fatigue, applicable to both cancer patients and healthy individuals. However, the variability in training protocols and insufficient emphasis on specific yogic techniques have left the exact elements responsible for fatigue alleviation ambiguous. This study intends to explore the impact of yoga-based relaxation methods—namely, Deep Relaxation Technique (DRT) and Cyclic Meditation (CM)—on muscle soreness and fatigue among female graduate athletes. This intervention-focused research aims to provide new insights into how structured yogic relaxation can facilitate post-exercise recovery, diminish delayed onset muscle soreness (DOMS), and improve neuromuscular performance. While prior research has underscored the overall physical and psychological advantages of yoga, this study will specifically concentrate on the physiological effects of yogic relaxation in athletic recovery. sEMG will be employed to track fatigue indicators, providing an objective assessment of muscular responses to the

intervention. Consequently, this research will bridge a critical gap by merging ancient yogic practices with contemporary scientific methodologies to analyze and comprehend muscle fatigue and recovery within a specific athletic demographic. The anticipated outcomes are expected to yield evidence-based recommendations for the incorporation of yoga relaxation techniques into sports training and rehabilitation programs, particularly for female collegiate athletes.

STATEMENT OF THE PROBLEM

This research seeks to investigate the effects of a 12-week yogic intervention that incorporates relaxation techniques on muscle fatigue and soreness in female athletes.

OBJECTIVES OF THE STUDY

1. To explore the relationship between muscle fatigue and muscle soreness with yogic relaxation techniques.
2. To assess the effect of relaxation techniques on muscle fatigue and soreness within the experimental group.
3. To compare the outcomes between experimental and control groups regarding the influence of yogic relaxation techniques.
4. To assess whether consistent practice of yogic relaxation can delay the onset of muscle fatigue during athletic performance.
5. To investigate the correlation between surface electromyographic (sEMG) signals and perceived muscle soreness post-intervention.
6. To explore whether yogic relaxation techniques can reduce the severity and duration of muscle soreness after high-intensity training.
7. To analyze if the combination of specific yogic techniques provides superior relief from fatigue and soreness compared to individual techniques.

RESEARCH QUESTIONS

1. Will cyclic meditation significantly affect muscle fatigue and muscle soreness?
2. Will deep relaxation techniques have a measurable impact on muscle fatigue and soreness?

3. Does the duration of training influence the outcomes on muscle fatigue and soreness?
4. Can surface electromyography (sEMG) effectively capture and associate changes in muscle fatigue and soreness among athletes?

HYPOTHESES OF THE STUDY

1. There will be a significant effect of cyclic meditation on reducing muscle fatigue and soreness in the experimental group compared to the control group.
2. Deep Relaxation Technique (DRT) will significantly reduce muscle fatigue and soreness in the experimental group compared to the control group.
3. The duration of the yogic training intervention will significantly influence the levels of muscle fatigue and soreness among the participants.

DELIMITATIONS OF THE STUDY

1. The study is limited to female athletes aged 18–22 years.
2. The sample consists of 45 female athletes from LNIPE, Gwalior.
3. The study focuses exclusively on muscle fatigue and muscle soreness.
4. The duration of the yogic intervention is 12 weeks.

DEFINITION AND EXPLANATION OF TERMS

1. Physiological Variables encompass quantifiable biological responses and functions, including heart rate, blood pressure, and neuromuscular activity, particularly in relation to stress, fatigue, and recovery.

2. Muscle Fatigue is characterized by a temporary reduction in a muscle's capacity to produce force as a result of repeated stimulation, involving both central (neurological) and peripheral (muscular) factors, such as energy store depletion (e.g., glycogen), metabolite accumulation (e.g., lactic acid), and compromised neurotransmission.

3. Muscle Soreness, commonly referred to as Delayed Onset Muscle Soreness (DOMS), describes the muscle pain and stiffness that typically peaks between 24 to 72 hours following

unfamiliar or intense exercise, often resulting from microtrauma to muscle fibers, particularly during eccentric contractions.

4. Surface Electromyography (sEMG) is a non-invasive method employed to evaluate and document the electrical activity of muscles, proving especially beneficial for analyzing muscle fatigue, activation patterns, and neuromuscular control during static or postural tasks. However, accurate signal interpretation remains challenging due to noise and technical constraints.

SIGNIFICANCE OF THE STUDY

This research aims to deliver significant insights into the efficacy of yogic relaxation methods—namely cyclic meditation and the Deep Relaxation Technique (DRT)—for alleviating muscle fatigue and soreness in female athletes. By investigating the impact of these techniques on post-exercise recovery, the study seeks to facilitate the creation of more effective, non-invasive recovery strategies that cater to the physiological requirements of high-performance female athletes. The results may aid coaches, athletic trainers, and sports scientists in formulating training regimens that minimize overuse injuries, expedite muscular recovery, and ultimately improve athletic performance. Furthermore, the research may assist in identifying athletes who could benefit from additional recovery methods or customized training modifications. A significant aspect of this study is its fusion of traditional yogic practices with modern sports science techniques. While earlier studies have recognized the overall health advantages of yoga, this research will concentrate specifically on its effects on muscle fatigue and soreness, employing objective measures such as surface electromyography (sEMG) to assess neuromuscular responses. In doing so, the study aspires to connect ancient relaxation practices with contemporary performance science, providing a comprehensive, evidence-based framework for athletic recovery and performance enhancement.

CHAPTER – II

REVIEW OF RELATED LITERATURE

The subsequent studies contribute to a foundational comprehension of the existing research:

Boyer et al. (2013) evaluated core muscle endurance in a sample of 1,502 children (ages 8–12 years; 52.5% female) utilizing a plank protocol. Their results validated that the prone bridge plank serves as a feasible, valid, and reliable instrument for assessing core endurance in children.

Cardozo et al. (2012) conducted a review of multiple studies that utilized non-invasive surface electromyography (sEMG) to observe back muscle activity across various populations, including healthy individuals, both trained and untrained subjects, as well as those participating in sports or ergonomic evaluations. The review pointed out discrepancies in sEMG findings attributed to the anatomical intricacies of back muscles. Some studies indicated increased, decreased, or statistically insignificant levels of muscle activity, likely affected by differing methodologies and generally small sample sizes—often ranging from 4 to 28 participants, predominantly male. Al-***Mulla et al. (2011)*** highlighted the significance of sEMG in clinical and athletic environments for tracking muscle fatigue. They remarked that advancements in EMG signal analysis and pattern recognition have greatly enhanced the ability to evaluate localized muscle fatigue during both isometric and dynamic movements. These developments aid in minimizing injury risk and improving athletic performance.

Field (2011) examined the physiological advantages of consistent yoga practice, which include pain alleviation, reduced heart rate and blood pressure, and enhanced muscle strength. The review underscored yoga's function as a comprehensive intervention for physical health.

Boyas et al. (2009) explored the coordination among synergistic muscles during prolonged isometric exercises. They noted significant alterations in muscle activity that were associated with enhanced endurance (time to task failure) in trained individuals. While both trained and

untrained subjects displayed typical sEMG patterns linked to fatigue, untrained participants demonstrated earlier and more pronounced fatigue.

Kant and Mishra (2001) investigated the influence of yoga on athletic performance, categorizing its benefits into four key areas: prevention of injuries, rehabilitation of injuries, enhancement of performance, and the maintenance of physical conditioning during and outside of competitive seasons.

Telles et al. (2000) assessed the effects of two yoga-based relaxation methods, Cyclic Meditation (CM) and Shavasana (SH), on oxygen consumption and respiratory patterns. In a study involving 40 adult participants, both methods led to decreased oxygen intake and slower breathing rates. However, CM, which combines dynamic postures with periods of rest, demonstrated a more pronounced physiological effect compared to SH alone. These findings indicate that the integration of movement with relaxation produces superior calming effects compared to passive relaxation alone.

Hagberg (1981) performed a small-scale study with nine male participants to analyze endurance times and EMG variations during sustained isometric and dynamic contractions. While endurance times were greater for dynamic tasks, there was no significant correlation between EMG changes and endurance duration. Nonetheless, both types of contractions showed similar declines in mean power frequency as a result of fatigue.

CHAPTER III

METHODS AND MATERIALS

This chapter delineates the methodology utilized in the current study. It elaborates on the selection of participants, the determination of sample size and study power, the identification of variables, the experimental design, the statistical analysis plans, the enrolment procedures, the testing protocols, the training regimen, the methods of data collection, and the statistical tools employed for analysis.

SELECTION OF PARTICIPANTS

A total of forty-five (45) female athletes from the Lakshmibai National Institute of Physical Education (LNIPE) in Gwalior, aged between 18 and 22 years, will be chosen for this study. Participants will be recruited using a random sampling method. Once selected, the participants will be randomly assigned to three equal groups—two experimental groups and one control group—each consisting of fifteen members. The respective intervention will then be administered to the experimental groups. Prior to their participation, each athlete will be required to provide written informed consent and agree to refrain from engaging in any other form of training or experimentation outside of their regular training and the assigned intervention during the study period.

SELECTION OF VARIABLES

The primary dependent variables selected for this research are muscle fatigue and muscle soreness. Muscle fatigue will be evaluated in both the core and lower limb (leg) muscles, while muscle soreness will be assessed through subjective measures.

SELECTION OF INSTRUMENTS

For the evaluation of muscle fatigue, surface electromyography (sEMG) will be employed. This non-invasive method measures the electrical activity generated by skeletal muscles and is extensively utilized in clinical diagnostics and sports science to evaluate neuromuscular function. The EMG measurement procedure involves preparing the skin surface with a 60–70% isopropyl alcohol solution to enhance signal conductance. Gel-based electrodes will be utilized for sEMG recording, which are appropriate for prolonged monitoring and are recognized for their reliability in detecting muscle activity in athletic contexts.

Muscle soreness will be quantified using the Visual Analogue Scale (VAS), a well-established subjective assessment tool. This scale consists of a straight line, typically measuring 100 mm in length, on which participants indicate their perceived level of pain. The left end of the line signifies the worst possible pain, while the right end indicates the absence of pain. Participants will mark their pain level accordingly, enabling the score to be expressed as a percentage.

DESCRIPTION AND ADMINISTRATION OF TESTS

To evaluate muscle fatigue in the core muscles, participants will be instructed to perform the prone bridge plank immediately following their training sessions. During the duration of the hold, electrodes will be affixed to the pertinent core muscles, and data will be captured using surface electromyography (sEMG) alongside timing recorded with a stopwatch. This testing will take place at the Sports Biomechanics Laboratory of LNIPE in Gwalior. For assessing lower limb muscle fatigue, participants will be directed to maintain the warrior pose (Virabhadrasana) at their maximum endurance. Electrodes will be positioned on the designated leg muscles to monitor electrical activity throughout the hold.

This assessment will also occur within the same biomechanics facility. To measure muscle soreness, participants will convene at the LNIPE girls' hostel and complete the Visual Analog Scale (VAS) to evaluate their pain intensity. Their scores will be documented for further analysis.

DATA COLLECTION PROCEDURE

Baseline (pre-training) data will be obtained from all participants prior to the commencement of the intervention. Mid-point data will be collected after six weeks of training. The final data collection will take place post-training at the conclusion of the intervention period for all three groups—two experimental and one control.

STATISTICAL ANALYSIS

The gathered data will be analyzed using a Two-Way Repeated Measures ANOVA (Mixed Design) to identify differences between groups and over time. The criterion for statistical significance will be established at $p < 0.05$.

EXPECTED OUTCOME

The study is expected to demonstrate that incorporating yogic relaxation techniques, specifically Cyclic Meditation and Deep Relaxation Technique (DRT), will significantly reduce muscle fatigue and muscle soreness among female athletes. It is anticipated that participants in the experimental groups will exhibit improved neuromuscular recovery, as evidenced by changes in surface electromyography (sEMG) signals and lower pain scores on the Visual Analogue Scale (VAS), compared to the control group. The findings may highlight the effectiveness of these yogic practices as non-invasive, holistic tools for enhancing post-exercise recovery, promoting muscle efficiency, and minimizing delayed onset muscle soreness (DOMS), thereby contributing to better athletic performance and reduced risk of overuse injuries.

REFERENCES:

1. Adkins, D. L., Boychuk, J., Remple, M. S., & Kleim, J. A. (2006). Motor training induces experience-specific patterns of plasticity across motor cortex and spinal cord. Journal of Applied Physiology, 101(5), 1776–1782. https://doi.org/10.1152/japplphysiol.00248.2006
2. Al-Mulla, M. R., Sepulveda, F., & Colley, M. (2011). A review of non-invasive techniques to detect and predict localized muscle fatigue. Sensors (Basel), 11(4), 3545–3594. https://doi.org/10.3390/s110403545
3. Allen, B. A., Hannon, J. C., Burns, R. D., & Williams, S. M. (2014). Effect of a core conditioning intervention on tests of trunk muscular endurance in school-aged children. The Journal of Strength & Conditioning Research, 28(7), 2063–2070. https://doi.org/10.1519/JSC.0000000000000460
4. Arabadzhiev, T. I., Dimitrov, V. G., & Dimitrov, G. V. (2014). The increase in surface EMG could be a misleading measure of neural adaptation during the early gains in strength. European Journal of Applied Physiology, 114(8), 1645–1655. https://doi.org/10.1007/s00421-014-2880-2
5. Bohannon, R. W., Steffl, M., Glenney, S. S., Green, M., Cashwell, L., Prajerova, K., & Bunn, J. (2018). The prone bridge test: Performance, validity, and reliability among older and younger adults. Journal of Bodywork and Movement Therapies, 22(2), 385–389. https://doi.org/10.1016/j.jbmt.2017.07.008
6. Van Boxtel, A., Goudswaard, P., van der Molen, G. M., & van den Bosch, W. E. (1983). Changes in electromyogram power spectra of facial and jaw-elevator muscles during fatigue. Journal of Applied Physiology: Respiratory, Environmental, and Exercise Physiology, 54(1), 51–58. https://doi.org/10.1152/jappl.1983.54.1.51
7. Boyas, S., Maisetti, O., & Guevel, A. (2009). Changes in sEMG parameters among trunk and thigh muscles during a fatiguing bilateral isometric multi-joint task in trained and

untrained subjects. Journal of Electromyography and Kinesiology, 19, 259–268. https://doi.org/10.1016/j.jelekin.2007.06.003

8. Boyer, C., Tremblay, M., Saunders, T., McFarlane, A., Borghese, M., Lloyd, M., & Longmuir, P. (2013). Feasibility, validity, and reliability of the plank isometric hold as a field-based assessment of torso muscular endurance for children 8–12 years of age. Pediatric Exercise Science, 25, 407–422. https://doi.org/10.1123/pes.25.3.407
9. Cardozo, A. C., Gonçalves, M., & Dolan, P. (2011). Back extensor muscle fatigue at submaximal workloads assessed using frequency banding of the electromyographic signal. Clinical Biomechanics, 26, 971–976. https://doi.org/10.1016/j.clinbiomech.2011.04.009
10. Cardozo, A. C., & Gonçalves, M. (2012). Assessment of low back muscle by surface EMG. In C. Steele (Ed.), Applications of EMG in Clinical and Sports Medicine (pp. 83–96). InTech Open. https://doi.org/10.5772/37382
11. Cholewicki, J., & McGill, S. M. (1996). Mechanical stability of the in vivo lumbar spine: Implications for injury and chronic low back pain. Clinical Biomechanics, 11, 1–15. https://doi.org/10.1016/0268-0033(95)00039-6
12. Debold, E. P. (2015). Potential molecular mechanisms underlying muscle fatigue mediated by reactive oxygen and nitrogen species. Frontiers in Physiology, 6, 239. https://doi.org/10.3389/fphys.2015.00239
13. De Luca, C. J., LeFever, R. S., McCue, M. P., & Xenakis, A. P. (1982). Behavior of human motor units in different muscles during linearly varying contractions. The Journal of Physiology, 329, 113–128. https://doi.org/10.1113/jphysiol.1982.sp014584
14. De Blaiser, C., De Ridder, R., Willems, T., Danneels, L., Bossche, L. V., Palmans, T., & Roosen, P. (2017). Evaluating abdominal core muscle fatigue: Assessment of the validity and reliability of the prone bridging test. Scandinavian Journal of Medicine & Science in Sports, 28(2), 391–399. https://doi.org/10.1111/sms.12719
15. Alam, K. K., Gangwani, N., & Mohan, M. (2024). Perception and practice of the eight limbs of yoga in yoga teachers: A cross-sectional descriptive study. Journal of Family Medicine and Primary Care, 13(4), 1500–1506. https://doi.org/10.4103/jfmpc.jfmpc_1711_23
16. González-Izal, M., Malanda, A., Gorostiaga, E., & Izquierdo, M. (2012). Electromyographic models to assess muscle fatigue. Journal of Electromyography and Kinesiology, 22(4), 501–512. https://doi.org/10.1016/j.jelekin.2012.02.019